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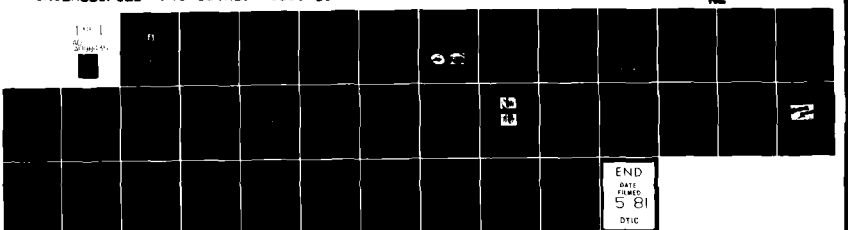

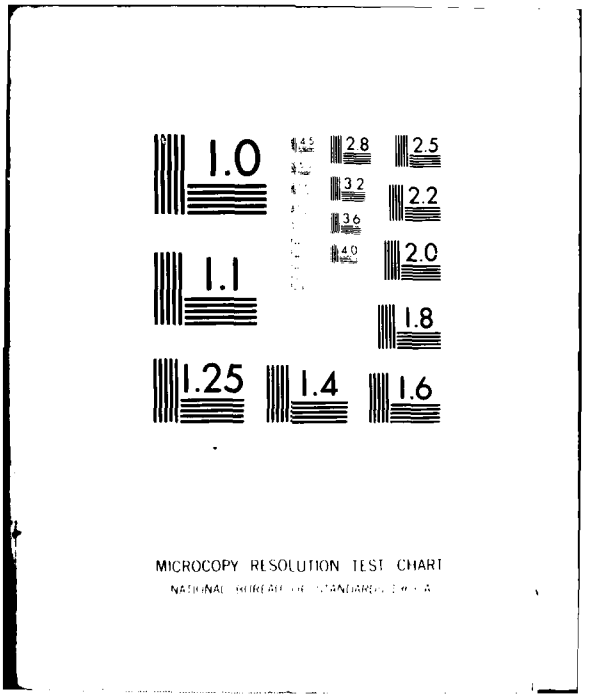
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THIRTY YEARS OF ACOUSTICS IN CHINA

by

Ma Dayou

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81 3 17 081

EDITED TRANSLATION

FTD-ID(RS)T-1839-80 4 Feb 1981

MICROFICHE NR: FTD-81-C-000016

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English pages: 34

Source: Acta Acoustica, Vol. 4, Nr. 11, 1979, pp. 241-250

Country of origin: China
Translated by: SCITRAN
F33657-78-D-0619
Requester: FTD/TQTR

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THIRTY YEARS OF ACOUSTICS IN CHINA

by Ma Dayou

(Institute of Acoustics, Chinese Academy of Sciences)

Acoustics developed early in China. Recorded accounts of acoustical theories date from the 6th century B.C. and it was only because of the oppression of feudalism and imperialism that acoustics and other branches of science are now seriously backward. In the thirty years since liberation, theoretical and practical work in acoustics have developed greatly so that an important force has formed contributing more and more to socialist construction. This article summarizes the academic activities and major contributions of China's achievements in research on acoustics.

Research on acoustics has a very long history in China, yet at present, like other branches of science, it is seriously backwards due to the oppression of feudalism and imperialism. Only after liberation in 1949 did acoustics research attain new life and gradually there was formed a research contingency with a fixed scale and level. They have achieved important results in their research and have contributed to socialist construction.

(1) Ancient Acoustics

In ancient times, China was one of the nations which made a contribution in acoustics. The Chinese people have a special love of ripples on the water and early, 6,000 years ago, pottery of the Yangshao culture had designs with ripples. During the first century A.D. (the Eastern Han dynasty), Wang Chong (in "Lun Heng") drew an analogy between sound and waves and brought forth a clear and definite concept of the nature of the wave motion of sound. Later, during the Song dynasty, Zhang Cai further mentioned that "sound is composed of a substance and air rolling" which explained the principle of a substance vibrating and producing sound and an airflow giving impulse to a substance and producing sound. This shows an early understanding of the nature of sound. At an even earlier date, it was mentioned in the "Preface to the Book of Poetry" that when sound is written down it is called tone and when tone is harmonized it then becomes music. Sound, tone, and music are different and generally this indicates the commonly used sound of written words. Noise is sound and the original long form of characters is also from tone, yet is is different from sound and tone. "The attached sound of noise is like the written form of a shadow" and therefore noise is the action of sound and especially causes people to produce a feeling (sound feeling). Noise then is "a group crying out and making a disturbance" ("Yu Pian") or "a disturbance" ("Shuo

.ven"). Strictly speaking, this shows an observation and understanding of an objective phenomenon. The size and shape of a vibrating substance influences the loudness of the sound, the dampening of the vibration and the distance of the dispersion of the sound. This was already discussed in the "Kao Gong Ji" at the end of the Spring and Autumn Period (5th century B.C.). At that time, the relation of the length, coarseness and loudness of sounds had already been determined. The use of resonance and resonators was mentioned in "Muo Zi". Ceramic was used under a stage or on a wall as resonators to amplify or absorb the sound. This was a commonly used acoustic fidelity control technique. The Echo Wall in Peking's Temple of Heaven (a smooth circular wall with a diameter of 65 meters which can cause a weak sound to be dispersed 100 or 200 meters on the edge of the wall), the Three Sounds Rock (an echo can be heard several times from the rock in the middle of Echo Wall) and the Surrounding Mound with a diameter of 23 meters which can produce an echo reflected from its railing were all constructed 500 years ago. The excitation of the side wall can bring about a spurting water basin (fish pond or double dragon pond) which was built in the Han dynasty (about 2,000 years ago).

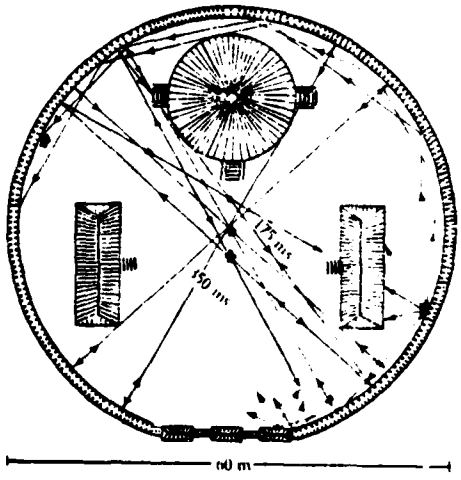


Chart 1 Echo Wall, Three Sounds Rock and Surrounding Mound of the Temple of Heaven (in chart 60m is division)

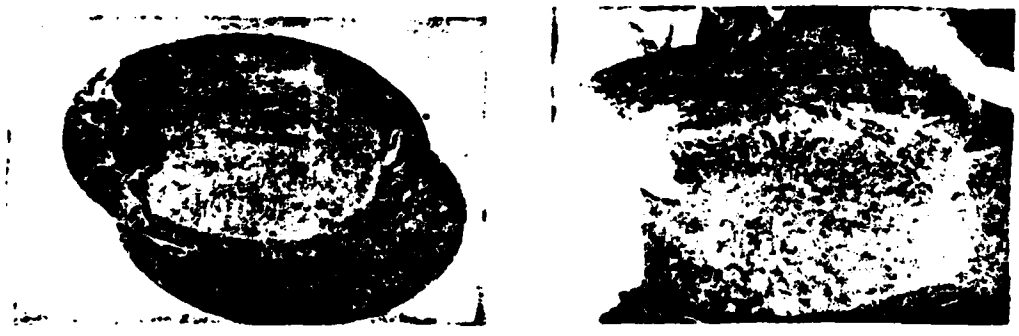


Chart 2 Spurting Water Fish Pond

In China, even more systematic research was done in music acoustics. It is recorded in the "Lu Shi Chun Qiu" that the Yellow Emperor ordered Ling Lun to use bamboo to make pitch pipes and he cut them to make the twelve tones. Fu Xi constructed the musical instrument qin and in three increases and decreases made thirteen sounds. Beginning from the Zhou dynasty (11th century B.C.), the use of music in ceremony became stronger as a governing means which is possibly a special characteristic of China. Because of this, research on musical tones and instruments was constantly given attention to. The pipes (vertical and horizontal flutes) were lengthened by one-third or shortened by one-third and this was very harmonious with the original sound. This is the earliest acoustic law, it had already been written of in "Guan Zi" in the 6th century B.C. and is still used for temperament. This occured at about the same time as Pythagoras of Greece but the latter used a long string. This can be seen as a favorable comparison of east and west. The use of the above mentioned twelve tones calculated by the three increase and decrease method does not quite occupy an octave but very early people recognized that one higher octave was a similar tone and because of this they designed various methods to attain this aim. China's 2,000 years of research on temperament seems to have been concentrated on using the three increase and decrease method to increase the tone number in one sound harmonic to attain the

correct value of an octave. 48, 60 and 360 tones were introduced historically in this way. During the Ming dynasty, in 1584, Zhu Zaiyu mentioned the $\sqrt[12]{2}$ that became the 12 tone equal temperament which is exactly the same as that used on a keyboard instrument in modern music. He is the earliest in the world to have mentioned 12 tone equal temperament yet it was not generally known at that time. This is a prominent example of how feudalism suppressed scientific work.

(2) Modern Acoustics

Up until liberation, China's work in modern acoustics was very backward. This is not because the Chinese people are not hard working. Early, about 100 years ago, there were people who gave attention to foreign writers on acoustics and brought their works into China. For example, there was a publication of a Chinese translation of Tyndall's "Acoustics." In the 1920's, Professor Chu Yuanren studied the special characteristics of the four tones. In 1929, Professor Ye Qisun and Shi Ruwei studied the problems of tone quality in the auditorium of Qinghua University and measured the sound absorption in Chinese style clothes. In 1941, Professor Zhou Tongqing of Fudan University used ultrasonics to measure the depths of the Yangzi River and the theoretical research on large scale turbulence done by Professor Zhou Peiyuan was also related to acoustics.

These were all pioneer works done within China. After 1936, Professor Wang Deshao carried out research on ultrasonics and the research done by Professor Qian Xuesen in 1946 on sound dispersion in thin gas was also carried out outside of China. Much of my own work on simple vibration theories was also done outside of China. 1927-1936 Domestically, there was basically no organized research, conditions for experiments were difficult and many hardworking scientific workers gradually became downhearted because of lack of support. Only under simple and crude conditions was Professor Liu Fu able to initiate research in ancient temperament and language acoustics (also called experimental linguistics) in the 1920's. This was also internationally advanced research at the time and later under the close guidance of Professor Luo Changpei, he continued his research on Chinese tone waves and attained important results.

Chart 3 One Page From Tyndall's "Acoustics"

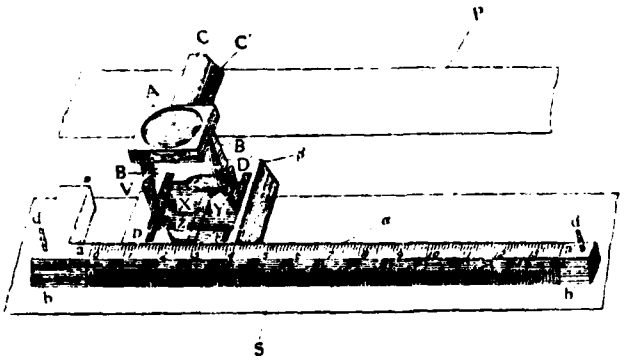


Chart 4 The Tone Infering Rule Invented By Liu Fu

(3) The Development of Acoustics in Thirty Years

If it is said that prior to liberation there were only a small number of scientists researching acoustics out of interest and a sense of responsibility to science and that work was done under difficult conditions and acoustics as a branch of science was deficient, then after liberation the situation must be said to be completely different. Taking myself as an example, I worked for 10 years in the old China, yet it was only after liberation in 1949 that I received my first tone quality consultant job and this was really a stiking contrast. Production power was liberated, each enterprise flourished and developed

and acoustics was no exception.

In 1956, under the personal care of comrade Zhou Enlai, there was formulated a long range twelve year plan for science and technology and from this acoustics was pushed forward and entered a stage of planned development. After the twelve year plan was nearly completed, in 1962 there was formulated a ten year development plan in which acoustics was formulated as a scientific development plan. During the cultural revolution, acoustics and other branches of science were devestated. After the "gang of four" were smashed under the leadership of comrade Hua Guofeng, in 1977 acoustics again became a basic science in the formulated ten year development plan wherein emphasis was placed on foundations and raised development targets. At present. all of China's acoustics workers are striving ahead with full confidence toward the advanced international standard.

In thirty years, most of the branches of acoustic research have been established from nothing. Professor Feng Jianquan (Huanan)., Professor Wei Rongfa (Nanking University), Professor Zhang Qifu (Tongji), Professor Du Lianyao (Peking University), Professor Chu Hengyuan (Shanxi Normal University), Professor Zhu Wuhua (Shanghai Communications University), Professor Wang Deshao and Professor Ying Songfu (Chinese Academy of Sciences) all carried out large scale organization and development work. There were also many units which set up acoustics work and the total number was no less than 70 or 80. Now, foundations have

been fixed in physics acoustics, marine acoustics, mechanical vibration studies, noise studies, ultrasonics, language acoustics, physiological acoustics, architectural acoustics, electro-acoustics, acoustic testing, atmospheric acoustics, geoacoustics and music acoustics. Attention has also been given to bio-acoustics and space acoustics. In China, acoustics has already formed into a whole classification of science.

There are at the least one or two and at the most 300 or 400 research personnel in each unit and the total number is close to 1,000 persons. The number of personnel and workers related to acoustics is even greater. Based on statistics, flaw detection without loss has the most and including workers reaches to 200 or 300 people. There are no less than several hundred people in electroacoustics, noise control, marine acoustic instruments and ultrasonics used in medicine. Because at the time when they began considering the development of acoustics the problem of technical expansion was taken into consideration, the technical contingency grew at the same time as the scientific research contingency. Today, it is easier to realize the integration of theory and practice and thus it is also convenient for the research contingency to develop.

A massive science organization of acoustics workers was also established. In 1964, the Acoustics Specialist Committee of the Chinese Physics Institute was set up and they published an acoustics journal on a fixed scientific level. After activities

were stopped during the cultural revolution, beginning in February, 1978, they prepared to continue work. Now, it has been changed to the Chinese Acoustics Institute and this year the acoustics journal has been restored with added coverage. Besides this, an appropriate organization was also set up in the Engineering Institute, a Flaw Detection Without Loss Institute was established within the Chinese Mechanical Engineering Institute, an Applied Acoustics Institute was established within the Electronics Institute and an Achitecture and Physics Committee was set up within the Architecture Institute.

In 1964, when the Acoustics Specialist Committee was established, the First All China Acoustics Conference was held. At the conference, there were 118 official representatives, 450 people from 150 units participated and 134 scientific papers were delivered including those in physics acoustics, marine acoustics, ultrasonics, electroacoustics, acoustic testing, vibration and noise, architectural acoustics, physiological acoustics and psychological acoustics. When the Chinese Acoustics Institute was established in 1979, the Second All China Acoustics Conference was held and the scope of the conference was much wider (aside from the above mentioned branches, there were also included music acoustics, atmospheric acoustics and geoacoustics). There were 200 official representatives and 340 papers delivered which was a very great development. During the cultural revolution, although scientific research workers had been devastated,

there were still many people who kept up their work and made great achievements. In 1973, acoustics circles responding to comrade Zhou Enlai's call to strengthen basic research, held an All China Acoustics Discussion Meeting in which 100 people participated and 85 papers were delivered. Many of the papers were signed and at the time this infuriated the "gang of four". This was actually a round of close combat with the "gang of four".

Besides the above mentioned conferences, many other conferences were held in the fields of architectural acoustics, ultrasonics, flaw detection, sound insulation, marine acoustics and environmental acoustics where there was the exchanging of experiences and the promotion of scientific research and technical work. In 1958, when the First Acoustics Conference was held, there were only 20 some odd people from all of China who participated and recently there were several hundred people who participated in the All China Examination Without Loss Conference. In the 1950's, there was no way to develop noise research but at the end of 1978 an Environmental Acoustics Conference was held with over 200 people participating and 193 papers delivered. Before liberation there was a deficiency in acoustics but today it has become a strong research force. Appropriate enterprises have been set up and it has become a more and more important force in national defense and in the national economy. Chinese acoustics workers have also been very active in international

activities. They have participated in conferences and paid visits to the Soviet Union, Czechoslavakia, Poland, Romania, East Germany, Hungary, Bulgaria, France, West Germany, Japan and the United States. They have also received many foreign acoustics specialists and established many individual contacts. There has been much activity in international cooperative work and in the future there will be even more.

(4) Important Contributions

In thirty years, acoustics developed out of nothing and the research contingency has gradually grown. On the one hand, this has helped industrial departments to set up and strengthen production in related areas, technical units (such as in ultrasonic equipment, marine acoustic equipment, broadcasting equipment, electroacoustical equipment, noise elimination and sound absorption equipment, musical instrument construction etc.) have allowed other departments to satisfy domestic needs and it has also nurtured industrial design and technical power. On the other hand, many achievements have been attained in research; besides completing a large number of national tasks, about 300 papers and briefs have been made public. At present, I can only briefly explain a small number of the more important research works and the list is far from complete. For the practical aspect of most of the work only a brief summary is presented.

1. Architectural Acoustics

Research in architectural acoustics began relatively early in China and it is a more familiar branch of acoustics. In ancient times, China had many achievements in architectural acoustics and some have been transmitted down to the present. After liberation, scientific workers carried out diligent research in this field using the methods of modern science and they elucidated on the principles of other sciences. For example, when researching Echo Wall, Three Sounds Rock and Surrounding Mound in Peking's Temple of Heaven, they attained rational explanations; they investigated the Fish Pond constructed in ancient China; when they researched the vibration principle on water surfaces and carried out model tests, they discovered that when the basin wall vibrated it could not only stir the water in the basin to spurt out but also under certain conditions could produce secondary harmonics (chart 5).

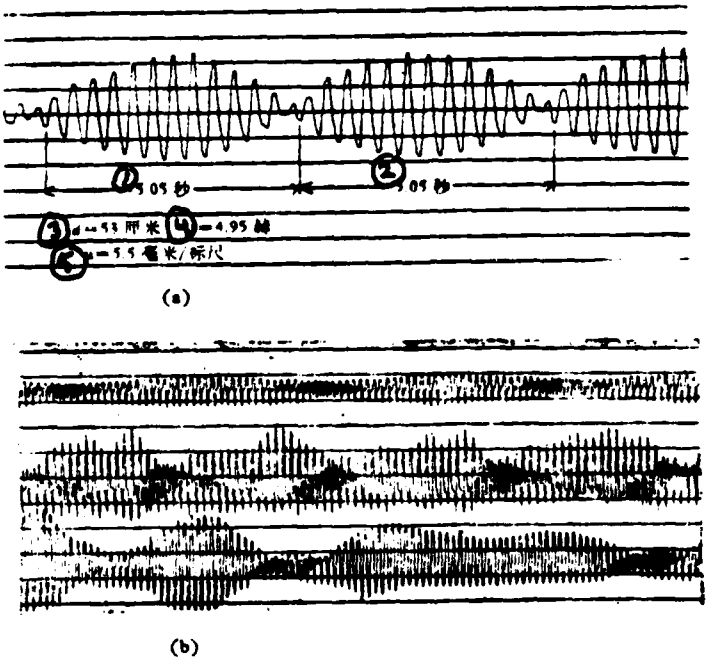


Chart 5 Secondary Harmonics in Waves

(a) When the amplitude is too great, there is only secondary harmonics (half frequency) on the water surface.
(b) When the amplitude is critical, the normal waves rotate and flow with the half frequency wave.

1. 5.05 seconds
2. 5.05 seconds
3. d=53 centimeters
4. f=4.95 hertz
5. μ=5.5 millimeters/staff gauge

In basic research, they continued research on the vibration

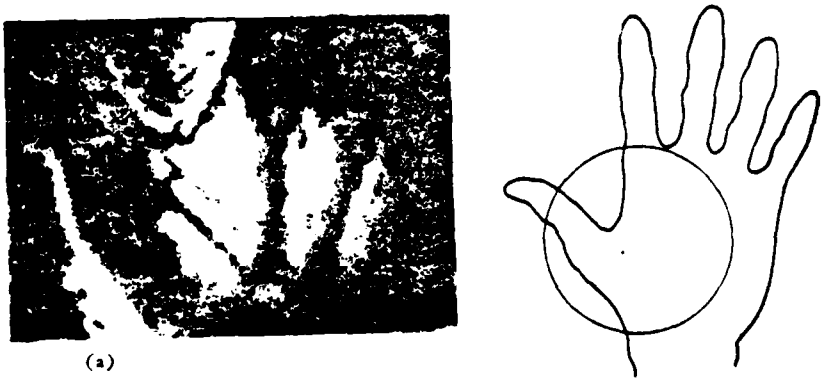
type theory and attained its directional distribution and the statistical distribution of sound vibration induced in a room (when a pure tone was excited, they obtained Rayleigh distribution and when a narrow band of white noise was excited, they obtained X^2 distribution). There was research development in model tests, electric spark sound sources and indoor impulse responses on the second tone quality evaluation. They also introduced the use of directional diffusion on a water plane to analyze tone quality in halls and for this there was developed a directional lens in the water plane. A directional microphone was also used to carry out a series of tests in directional distribution. On the foundation of these works, in 1959 various acoustics units in Peking undertook the consulting work for tone quality design in the Great Hall of the People and after construction was finished they carried out sound field measurement and clarity tests. In this 90,000 square meter great hall, sound absorption materials and dispersion and semidispersion loudspeaker systems were used so that an audience of 10,000 could clearly hear political reports or enjoy music. Today, this can still be regarded as an outstanding achievement and can provide experience for later workers. The achievements in tone quality design were relatively great and not only in the domestic construction of a large place with excellent tone quality. For example, in the last ten years, the tone quality in many broadcasting rooms, auditoriums, theaters, recording studios etc.

(in Peking's Capital Gymnasium, the Hangzhou Theater, gymnasiums etc., aside from gymnasium competitions, there can also be music performances which is also an important international development) has been successfully designed by Chinese acoustics workers for friendly third world nations. In the field of acoustic materials, much research has been done on porous sound absorption materials, attention has been placed on the damping of materials and also many man-made materials have been developed. A great deal of work has been carried out on sound insulation structures and methods of measuring sound insulation. Special attention was given to sound insulation of light structures and appropriate methods of measuring have been introduced.

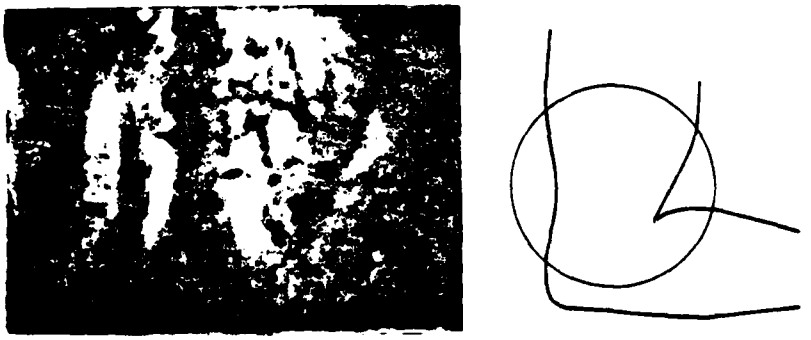
2. Ultrasonics

Ultrasonics is also a branch that was early given attention to in China. Early, in 1952, much work was done in ultrasonic flaw detection. After the twelve year plan was organized, especially the application of ultrasonics (flaw detection, processing, seed treatment, indication and medical treatment), ultrasonics developed even further. In 1959, successful tests were carried out in crushing dyes, emulsification and seed treatment all of which gained a lot of attention. However, in 1960, some comrades exaggerated the use of ultrasonics and an "ultrasonic wave movement" was set off all over the country. The

overexaggerations caused a mass reaction and presented difficulties for ultrasonic work. It was only after two years that research was again healthily carried out. Later, technical departments also conscientiously established an ultrasonic application contingency and an ultrasonic equipment industry which already has a firm foundation. In the area of basic research, they studied the problems of ultrasonic vibrations of a rod, ultrasonic emulsification and ultrasonic absorption of bubbles in water; they established experimental equipment for molecular ultrasonics and carried out research on ultrasonic absorption of a suspended substance and relaxation absorption; they set up measuring equipment for ultrasonic loss in solids and carried out a large amount of work; they carried out extensive research on the velocity of sound and loss of viscoelasticity and compressible flow substances. All of this work was done during the 1950's and the beginning of the 1960's. In 1965, research was begun on the surface wave transducer, In 1970, research began on high frequency surface waves and in 1977, they triumphantly completed the first domestically manufactured surface wave pulse compression wave filter. Now, surface wave devices are being produced and used in machines and their performance is excellent. In 1972, they began research on sound holographs and they were used to show substances under water (chart 6).



(a)



(b)

Chart 6 Sound Holographs

(a) The relatively evident pulse ultrasonic center frequency in the tendon between the thumb and index finger is 3.2 MHz and the multifrequency emission band width is 350 kHz.

(b) On the area of the upper arm and lower elbow, the pulse ultrasonic center frequency of the skeleton, blood vessels, tendons etc. is 3.2 MHz and the multifrequency emission band width is 350 kHz.

There has been relative success in ultrasonic investigation and ultrasonic treatment with Chinese medicinal herb seeds. The measurement of sound velocity in fluids has already reached a higher accuracy level (10^{-5}) and therefore it can be used to seek the composition and current velocity of fluids in vessels. In medicine, ultrasonic diagnosis has already reached a stage of maturity, for example in reattaching severed limbs and in investigating whether or not a blood vessel has any sensitivity. Ultrasonic curing has attained achievement in many important areas and in recent years research which was begun on Doppler ultrasonic diagnosis has also been relatively successful. In 1978, a special conference to exchange experiences was held. Piezoelectric crystal and ceramic materials are the main transducer materials used by ultrasonic workers. During the period just after liberation, research was continued on piezoelectric quartz and soon after the Rochelle salt crystal began to be produced and extensively used in microphones, adapters and hydophones. In 1963, barium titanate materials were formally appraised and produced and research in the field of piezoelectric materials was not only successful but the supply was early already self-sufficient. In recent years, the introduction of buoyancy to pull out monocrystals as well as pulling out section shaped and tube shaped crystals has been significant for the development of high frequency piezoelectric materials ($LiNbO_3$). Research on ultrasonic microscopes and special

ultrasonics has already begun.

3. Marine Acoustics

Before liberation, marine acoustics was completely lacking in China and only after the 1956 long range plan did it begin to develop. Much work has already been done in this field. They have already carried out large scale marine acoustic measuring in China's continental shelf, the South China Sea and the Pacific Ocean. Test patterns have been obtained for various types of hydrological and geological conditions in shallow sea waters, deep sea sound paths and the sound dissemination, absorption, reverberation, scattering, irregular fluctuations, correlation, wave distortion and natural noise of the accumulated mass of material in convergent areas. A great deal of theoretical work was also done. During the period from 1960-1962, a creative contribution was made towards the simple wave theory and they attained the index attenuation coefficient of the maximum simple wave (formula) by using the indicated formula of the reflex coefficient and span on the sea floor. For the arbitrary sound velocity distribution, they used the integral method to attain an approximate understanding of the sound field. This provided a more common formula which caused the special characteristics of the simple wave to have a clear and distinct physical image. In 1964, similar results were published abroad. The relationship of reverberation, wind noise and environmental

factors was also analyzed. The advancement of the method based on the sound field measurement of the sea floor reflection special characteristics also brought about creative results. The large angle of the reverse scattering on the sea floor was also measured and theoretical research was done on the shallow sea sound wave irregular fluctuations and noise. There were introduced the concepts of a noise field local chart and a local chart scale whereby important results were obtained. Also mentioned was the existing possibility of "low noise information channels." The numerically calculated results of the electronic computer matched the tests. Analysis of the average power chart, dynamic chart and linear chart for naval vessel radiation noise was carried out. Theoretical analysis was done on the problem of the simple wave sound field of a directional plane radiator in a delamination medium, smoothing and average sound field calculations were carried out in research on deep sea sound fields, calculations were carried out on the sound field fine structure of deep sea reverse point convergent areas and these were compared to test results. Besides these, research was also carried out in laboratories on sea water absorption and the local sea water scattering coefficient and sound wave propagation in suspended liquid or a pure high mountain. This developed theoretical and experimental research on non-linear acoustics and established a reference point for experiments. A computer program was drawn up to make preliminary predictions on shallow

sea sound fields.

Much work was done in the field of marine acoustic transducers and there were notable achievements. Many types of transmitting transducers were developed. Among them, the curved tension type piezoelectric ceramic transducer has a wide frequency band, its unit power is large, its weight is small and it produces a high powered emission transducer and an excellent responding emission transducer with a frequency in the 1-10 kilohertz range. Many types of receiving transducers were developed and the manufactured BS-1 type lithium sulphate standard hydrophone has an operating frequency band of 20Hz-100kHz and its temperature stabilization is good. Many types of marine acoustic instruments and equipment were developed which made a technological contribution to the fishing industry and navigation. At present, China is basically self-sufficient in the areas of marine acoustic transducers, instruments and equipment.

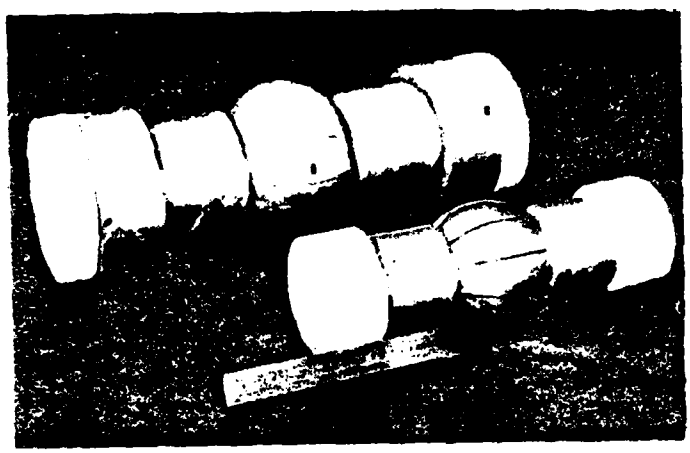


Chart 7 Curved Tension Type Transducer

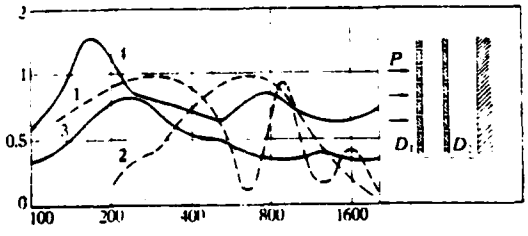
4. Noise and Noise Control

This area of research was not only deficient in China before liberation but during the 1950's, it developed very rapidly outside of China. China's research on noise was energetically started by some comrades at the end of the 1950's. However, at that time China's industries were still very weak and the noise problem was not placed on the agenda so that development work was very difficult and it did not have any great use. Yet, the work of other fields were influenced and only after several

years was work begun. This is also a lesson in scientific organizational work. Because of the gradual increase in objective demands there was greater development during the 1960's. Especially notable was the placing on the agenda of environmental protection. Environmental protection groups were established nationally and each province and major city also set up environmental protection groups. Some also established institutes and the epidemic prevention stations in each locality also gave attention to the problem of environmental protection. Noise research by research units also developed tremendously. Generally, methods for the control of noise such as sound absorption, sound insulation, shock absorption, earflaps and sound insulation covers are already in general use and the various localities have had a great deal of success in using these measures. The use of the simple method of destructive spatial resonance to decrease noise and vibration has been effective in many situations. Systematic investigations were done on various types of workshops and based on them, a plan was proposed wherein one type had the sound source accorded to the sound level and another type accorded to the frequency spectrum. A large number of investigations were done on the influence of noise on people and much data has already been collected on the influences in the physiological functions of hearing and non-hearing and the hearing of language. On the basis of this data and foreign

experiences, the guiding range for a noise standard was formulated wherein hearing and health protection (in an 8 hour work day) were 75-90 dBA. For indoor work (language, thinking), it was 45-60 dBA and for outdoors there was added 10 dBA. For the sides of main lines of communication there was added 10 dBA and at night it was decreased by 10 dBA. All of these were mean values or equivalent values. At present, health and labor protection departments have already stipulated that on each 8 hour work day, the highest permissable standard was 90 dBA, in newly constructed enterprises 85 dBA was required and for each additional 3dBa the time was decreased in half. The impulse sound (including gun sounds) standard is also being worked out and the tendency is that the highest limit of a single shock transmitted from the front is 177 dB (peak value) so that with each ten fold increase the noise level must be decreased 6 dB. For example, if there is a tail sound (reverberation), then from the peak value change of 20 dB continuous time from 1 millisecond of each ten fold increase there must be decreased 6 dB. These and other standard formulations are beneficial for the development of noise control. A great deal of measurement and analysis has been done on communication noise and the above mentioned guide range for noise on the sides of roads is based on these investigations and they are considered rational and possible. At present, the major problem in China's transportation is the sound of horns. They have raised the average peak value of noise about 10 dB which has caused China's cities to

seem like the noisiest cities in the world. To control China's communication noise, the first problem is improving communication supervision by forbidding non-emergency or night horn blowing. This has already been done in some cities. Only if we overcome the sound of horns can other technical measures become effective. They have researched the sound of moving vehicles and formulated a standard. Much measurement and analysis has been done in the field of sound absorption and slag brick for absorbing sound has been developed. In 1966, there was introduced a porous material and the decreased microperforation board structure of the small aperture developed in theory and practice (chart 8).



(1) d=0.75 t=1 b/d=4.7 D=0.08
(2) d=0.75 t=0.5 b/d=7.7 D=0.24
(3) d=0.75 t=0.5 b/d=7.7 D=0.20
(4) d=0.75 t=0.5 b/d=7.7 D_1=0.08 D_2=0.16
(b/d 为孔距与孔径比①)

Chart 8 The Double Layer Microperforation Board Structure and Its Absorption Properties

1. b/d is the ratio of the aperture and the hole distance

Besides its successful use as a sound absorption structure under adverse conditions, it proved to be effective on various sized silencers and the influence of wind velocity on it was very small. The introduction of the simple value indication method for sound insulation properties which uses a 500 Hz sound insulation quantity or a sound incidence at C sound level and sound transmission at A sound level difference is a problem which has gained attention and is being discussed further. In the areas of sound source power, sound insulation and reverberation measurement, the impacter was introduced as a standard sound source. This method is both simple and stable. Gas sound sources which have made their appearance in many places (from rockets and jet planes to antiaircraft missiles and pipe gas leakage) have also been given more attention. With the use of A sound level to indicate the radiation field of the air flow noise there was obtained the turbulent flow noise which was the function relation of the air chamber pressure. From this, further understanding was gained concerning turbulent flow movement. One important conclusion was that when the noise (using A sound level) produced by the outflow of each unit surface under the same air chamber pressure was made into a ratio with the diameter of three sides, this allowed the results of the small holed diffusion silencer to be able to be calculated in advance. A great deal of work was also carried out on the open holed pressurizer. Initial results have already been gained in lowering vehicle

noise and raising efficiency with the correct usage of the silencer. The control of air flow noise can be managed in different situations. The use of sound insulation covers and vibration insulation are effective for the control of impact noise and impact noise is lowered over 30 dB in cement structures and on cement ball mills. Yet, research on sound sources has only just begun. Work has also begun on strong noise environments and 168 dB travelling wave tubes and 152 dB reverberating chambers have been set up. Furthermore, research has been done on the problem of sound fatigue and many tests have been carried out on animals. In investigations on wave shape changes and saturation under high strength, it was discovered that the harmonic production estimated from the saw-tooth wave was high and this is an interesting problem in non-linear acoustics.

5. Language Acoustics

Language acoustics research begun in the 1920's is still being continued but the range has become even wider. Industrial departments also have development units in language communication equipment. A great deal of vowel frequency spectrum analysis has been carried out and from the frequency spectrum measurements seeking a resonance peak, technical measurement research has also been done on tones. Research was done on the vowel frequency spectrum, the mean frequency spectrum of Mandarin

Chinese and the clarity test method. The language noise method was introduced independently and much measurement work was done. Research was also carried out on the language analysis compound system. With the organization of language statistical work, based on the statistical results of 70,000 Mandarin Chinese words, the frequencies of vowels, consonants, tones and syllables (of Chinese characters) were obtained. They also obtained the frequency of each letter and of two letters joined when using the Chinese phonetic alphabet to write out the letters. They formulated an articulation test character table and attained the relationship among various language unit articulations and the influence of various conditions (for example, volume, frequency band,information noise ratio etc.). From this, some language articulation patterns were deduced. In experiments on Mandarin Chinese, the articulation of tones seems not to be influenced by conditions and there are very few errors. Based on these phenomena, the tone changes and consonant properties were stressed in the sounder and using 2,400 Bitter each second there could be attained a higher degree of comprehension and naturalness thus allowing the frequency channel sounder to reach a practical level. Based on the demands of the international telegraph and telephone consultative committee, they also determined the mean frequency spectrum of the Chinese language. In this type of work, it was discovered that the mean frequency spectrum was influenced slightly by language sound level (when

speaking in a loud voice the frequency spectrum generally shifted to a high frequency). Because of this, when we speak of a mean frequency spectrum we should explain the language sound level. In language automatic discerning, there has been great development since the discernment of 10 vowels in 1961. Suitable frequency spectrum sampling was used in electronic computers, the time returned to one and with the use of the pattern comparative method there was attained a high rate of accurate discernment (about 99%). Although this is only suitable for a limited number of words (several ten to several hundred), automatic system spoken language operation in computer imput is already close to application.

6. Electroacoustics and Measurement

As previously mentioned, there have been many achievements during the last thirty years in the areas of piezoelectric crystal and ceramic materials. At present, various types of microphones are being produced. In the field of capacity microphones, China has designed a method which uses diaphragm plating directly to the outer casing and this satisfies the demands for stability and temperature coefficient in standard microphones. Stationary polar microphones are also being produced and there has been development in the direction of high quality stationary polar capacity microphones. Achievements have been gained in the fields of noise resistant microphones

and crystalline loudspeakers. Research on curve tension type hydrophones and modulation airflow loudspeakers has attained to several megawatt sound power radiation and a wide frequency band standard hydrophone has also been completed (as previously mentioned). Sound pressure standards for air sounds and water sounds have been established and a more accurate method has been formulated. There is some foundation in acoustic measurement instruments. Yet there are still difficulties and we are still far from being completely self-sufficient. However, there have also been achievements. Research was done on statistical analysis equipment and at the end of the 1960's development and production of a three dimentional frequency spectograph was completed. Since the use of electronic computers, there has been completed the fast Fourier analysis computer program (Basic and Fortran) design software to program the component parts in the warehouse. Recently, with the faster speed they can manufacture the real time analysis FFT hardware and this has already been put into production. There are twelve functions: the FFT, IFFT, ODFT, self powered spectrum, mutual power spectrum, convolution spectrum, self phase spectrum, convolusion numeral wave filter, probability density and instantaneous catch and A/D transformer. All of these can be integrated in commonly used computers. Each unit has set up sound field laboratories (reverberation rooms, sound insulation rooms, silencing rooms, test ponds etc.) and many have reached to a higher level thus providing conditions for test work.

7. Other Fields

Other work has been carried out in the fields of physiological acoustics and hearing electrophysiology and many animal tests and human comparisons have been done on the influence of shock sounds. Much investigation has been carried out on the influence of strong noises on the human body which has helped toward the formulation of noise standards. Research was also carried out in the fields of atmospheric acoustics and geoacoustics wherein it was discovered that the secondary sound wave produced by a typhoon occurs in about 6 seconds and a suitable method can be used to determine its direction. Besides producing seismic waves, earthquakes also produce secondary sounds which can be audible sounds or supersonic. Acoustical methods can be used to measure seismic wave sensitivity. Besides this, earthquakes also produce low frequency sounds in the air and this part (and the above supersonic) which is transmitted from afar or produced in the area awaits further examination and is worthy of attention. Secondary sound receivers and monitoring systems have already been established and we are basically self-sufficient in equipment. Much work has also been done in music acoustics and there have been achievements in research on musical instruments and electric musical instruments. A great deal of research has been done on stereophonics and the musical instrument manufacture industry has researched the problem of the Chinese paulownia being used as a resonating board.

Generally speaking, the development and achievements over

the last thirty years have been great. In 1964 and 1965, China's acoustics contingency was already relatively mature and began producing results which can be seen from the acoustics journals of that time. During the cultural revolution and the turmoil of Lin Biao and the "gang of four" this field really declined and a great distance was created with international development. After the smashing of the "gang of four", the acoustics contingency was reorganized and began to advance quickly. From now on, under the guidance of the Party Central Committee with comrade Hua Guofeng as the leader, taking acoustic development plans as a guide, scientific democracy will be fully developed, cooperation will be strengthened, repetition will be avoided and under possible conditions planning and experimental technology levels will be raised. Taking the advanced international level as a starting point, it is necessary that we quickly move to the forefront of the world.

Summary

THIRTY YEARS OF ACOUSTICS IN CHINA

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The science of acoustics emerged in China early, acoustical theories in written form appeared as far back as 6th century B.C. and it was only due to the oppression of feudalism and imperialism that acoustics together with other branches of science declined in recent years. In these thirty years after liberation, work in acoustics, both theoretical and practical aspects, flourished astoundishingly, and important force is formed, contributing more and more to the socialistic reconstruction. The growth of the acoustical community, the academic activities and the main contributions are reviewed for this period.

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